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Growing

Safflower

Agricultural Research Service
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CONTENTS

	Page
Description-----	1
Current and potential production areas-----	2
Economic factors-----	2
Uses-----	3
Price-----	3
Yields-----	3
Adaptation-----	3
Temperature-----	4
Moisture-----	4
Soil-----	5
Place in rotation-----	5
Varieties-----	5
Seed treatment-----	6
Planting dates-----	6
Cultural practices-----	8
Soil preparation-----	8
Fertilization-----	8
Planting-----	8
Solid drilling-----	9
Rows-----	9
Broadcasting-----	9
Cultivation and weed control-----	9
Irrigation-----	10
Harvesting-----	11
Insects-----	12
Diseases-----	13
Rust-----	13
Root rot-----	14
Leaf spot-----	14
Bud rot-----	15
Other diseases-----	15

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G R O W I N G S A F F L O W E R

Safflower ^{1/} is an oilseed crop adapted to the wheat and barley areas of the western United States that have dry atmospheric conditions during the latter part of the growing season. It is the source of a marketable oil that is used mainly by the paint and varnish industries. Meal provides a by-product of some value as a livestock and poultry feed supplement.

The crop has been known for centuries in India, the Middle East, and North Africa, where it is used as the source of a dye and an edible oil. Safflower was introduced experimentally as an oil crop in the United States in 1925. American farmers began growing safflower commercially about the end of World War II.

Varieties yielding about 35 percent of oil are available for commercial production. Plant breeders are continuing to increase the oil content and improve the crop.

DESCRIPTION

Safflower is an annual plant of the thistle family. Commercial varieties in the United States are spiny. Present spineless varieties are not grown in the United States, because of low oil content of the seed or low yielding ability.

The plant has composite flower heads with green bracts. The color of the flowers varies with the variety and may be yellow, red, orange, or white.

Each central stem produces 1 to 5 or more flower heads, each containing 40 to 100 florets. A floret at maturity bears one seed which is about the size of a barley kernel.

The plant develops sturdy taproots. It forms oblong, waxy leaves that grow slowly in flat rosettes at ground level for 4 or 5 weeks. With warmer weather and longer days the plant grows upright. It begins branching from the woody central stem when the plant is 8 to 15 inches high. Safflower reaches its full height of 18 inches to 5 feet at the time it flowers.

Safflower matures in 110 to 150 days as a spring-planted crop and in 200 or more days as a fall-planted crop.

^{1/} Carthamus tinctorius L.

Safflower seed weighs between 37 and 48 pounds per bushel, depending on the variety and other conditions. The hull is the heaviest part of the seed; it accounts for one-third to one-half of the total weight. The seed also contains between 26 and 37 percent of oil, between 11 and 17 percent of protein, and between 5 and 7 percent of moisture.

Safflower usually will not grow as a weed. Competing wild plants will overshadow it during its slow growth after emergence, so that it does not become established.

CURRENT AND POTENTIAL PRODUCTION AREAS

Safflower is adapted to the Northern Great Plains, the Pacific Northwest between the Cascade and Rocky Mountains, and the southwestern part of the United States. Production has been most successful in the central valleys of California. Safflower has at times been successfully produced in parts of all States west of the 100th meridian.

The crop was first grown commercially on the dryland wheat area west of North Platte, Nebraska. In some parts of the Great Plains, and in California, safflower has been grown under irrigation. In California it is grown mostly on dryland, usually following an irrigated crop. Safflower is not adapted to the Corn Belt or the Eastern or Southern States.

About 100,000 acres were planted in the United States annually in 1956 and 1957.

ECONOMIC FACTORS

Because safflower is a relatively new commercial crop, the market still is not fully developed. Usually it is grown and sold under contract. Some processors pay the market price at harvest; others guarantee a fixed price per ton to the growers. Before deciding to plant safflower for the first time, farmers should discuss the sale of the crop with an established contractor, processor, an experienced grower, or the local county agricultural agent.

Safflower is planted, cultivated, and harvested with the same machinery as small grains. The cost of growing safflower may be compared with the cost of growing barley or wheat.

In experimental plantings in Arizona in 1956, the cost of growing safflower totaled about \$10 more per acre than the cost of growing barley. This was due to the costs of two extra irrigations. In California, the cost of growing the crop on dryland was about the same for barley.

Harvesting safflower is about as expensive as harvesting wheat, however, the combine operates at a slower rate.

Uses

Safflower oil is light in color and can be clarified easily. It is nonyellowing when used in paints and varnishes. Newest use of safflower--as an edible vegetable oil for human diets--may have some potential. Processed oil contains a higher percentage of unsaturated fatty acid than other vegetable oils.

Meal or seedcake supply protein feed supplements for cattle, sheep, and poultry. Meal from whole processed seed may contain between 18 and 24 percent protein. Processed safflower from decorticated seed will contain 28 to 50 percent protein, depending upon amount of hulls removed.

Price

Safflower oil sells for about the same price as linseed or soybean oil. The seed sells for about 2 times the price of barley. In 1957, seed brought an average of \$74 a ton in California.

Yields

Safflower yields vary greatly, depending upon variety, growing conditions, and method of cultivation. In California, safflower yields about 90 percent as much per acre as barley.

Yields are reduced by poor land, improper seedbed preparation, weeds, late planting, too early harvest, disease, and insects. Frost on an unripened crop will decrease the oil content.

Top yields of 4,800 pounds of safflower seed per acre have been produced on irrigated and subirrigated land in California. In contrast, some dryland farms in poor years have produced yields of less than 300 pounds per acre. In 1956, the California average yield was 1,700 pounds per acre on 80,000 acres.

Production on fallow land in the Great Plains and Pacific Northwest may be as much as 2,000 pounds of seed per acre under dryland conditions in favorable seasons. Most yields can be expected to be between 700 and 1,200 pounds per acre.

ADAPTATION

Safflower is adapted to those areas which have dry atmospheric conditions during the latter part of the growing season. It requires adequate soil moisture from planting time through flowering for good growth. Safflower is somewhat tolerant to drought after flowering.

Cool, short days following emergence are necessary for root growth and development of the rosette stage. Higher temperatures and longer days promote stem growth and flowerhead formation. Dry atmospheric conditions during and following flowering are essential for proper seed set and high oil content.

Safflower is more tolerant to wind and hail than barley and small grain. It does not lodge or shatter easily after it is mature. Safflower may be seriously damaged by hail in the stem-growing (or succulent) stage, which lasts about a month.

Temperature

Safflower should be planted when the soil temperature is about 40° F. At temperatures below 40° F the plant may take 30 days to emerge. Seeds germinate quickly at temperatures near 60°.

Seedlings can withstand temperatures of 20° F. However, when plants are 4 or 5 inches tall they may be damaged by temperatures below 25°. Varieties differ greatly in amount of frost tolerance. Freezing temperatures will damage safflower that is budding or flowering. When the stem freezes, the center gradually darkens and the plant dies.

A frost before maturity may reduce the quality and yield of the seed.

Moisture

Safflower may be grown under irrigation, as a dryland crop, or under subirrigation on high water table land. The crop needs soil moisture from the time it is planted through flowering.

For a maximum yield, safflower needs soil moisture equal to 25 inches of rainfall a year. Soil moisture equal to between 12 and 18 inches a year will yield a satisfactory crop in an alternate crop-fallow system. On land with no moisture reserve, safflower should receive about 12 inches of rain or irrigation water during the growing season. Late winter rains are beneficial.

In the southwestern part of the United States, where total irrigation is required, safflower will need 3 to 3 1/2 acre-feet of water, or about 2 irrigations more than small grain.

Moisture to a depth of 4 feet at planting time is required when safflower is grown under dryland conditions. With insufficient moisture, plants may fail to produce a satisfactory yield.

In late spring, safflower needs more moisture than small grains. Spring-planted irrigated safflower requires 2 to 4 irrigations.

Rains during ripening and harvesting periods may reduce seed yields.

Soil

Clean, weed-free land should be used. Safflower will grow on well-drained land of average texture and fertility. It thrives in deep sandy or clay loam soils with adequate drainage.

Safflower grows best on soils that are neither too acid nor too alkaline. The plant has about the same tolerance to alkali as barley.

On light soils that are irrigated, safflower may reduce soil blowing. Enough stubble will be left during the winter to prevent wind erosion.

Place in Rotation

Safflower often replaces barley or other small grains in rotation. It matures too late to be used in double cropping.

Highest safflower yields on dryland follow summer fallow. Safflower can follow wheat, corn, legumes, potatoes, beets, or rice, as well as grasses and clover on irrigated land. It may need nitrogen when planted following small grains. Safflower should not follow itself in the rotation because of disease hazards, particularly on irrigated land.

Late-planted crops, such as potatoes, beans, and corn, may produce higher yields than small grains following safflower.

VARIETIES

Varieties differ in flower color, degree of spininess, diameter of seed heads, oil content, and resistance to disease. Plant breeders continue to introduce new varieties with higher yields and disease resistance.

The two varieties that are grown most widely at present are N-10 and Pacific 1.

N-10 is adapted to dryland and subirrigated production. It has yellow flowers, grows rapidly in the early stages, and matures moderately early. It is susceptible to rust and root rot. N-10 contains from 28 to 37 percent of oil.

Pacific 1 is an improved variety similar to N-10. It has orange flowers, grows rapidly in the early stages, and matures early. It is resistant to one race of rust. It is susceptible to root rot. Pacific 1 contains from 28 to 37 percent of oil.

A number of new varieties are in various stages of increase and are expected to replace N-10 and Pacific 1 in the near future.

SEED TREATMENT

Seed that is to be used for planting should be cleaned to remove foreign matter, weed seeds, and small grains. Wheat, oats, and barley are particularly difficult to separate from safflower. If more than a trace of these grains is present it may be desirable to obtain seed completely free of them.

Treating the seed with a fungicide is recommended primarily for control of seed-borne rust and Alternaria. These fungi, in addition to causing loss in stand, also cause foliage diseases. The fungicide treatment helps to insure uniform stands of vigorous plants by killing fungi on the seed and protecting the germinating seed from soil organisms.

Seed should be treated with a volatile mercury fungicide, such as Ceresan 75 a/ or Panogen 15, b/ at a dosage of 1 to 2 ounces per bushel. Other similar volatile mercury formulations may be used at dosage rates determined by the concentration of the active ingredients or at the dosage recommended for flax seed. Seed processors or wholesale seed distributors usually treat seed before selling it to growers.

Treated seed should be plainly tagged or labeled: Treated seed - Poisonous - Do not use for food, feed, or oil purposes. Seed should be treated with lindane, 2 ounces per bushel, where wireworms are a problem.

Treatment should be applied at least 24 hours before seeding. Treated seed can be stored for several months.

PLANTING DATES

Safflower may be planted in the fall or winter in the irrigated valleys of southern California and those of Arizona. The planting date is later when safflower is grown farther north. In the Northern Great Plains, the crop is planted in the spring.

Date of planting will be governed by local conditions, including spring temperatures, weeds in the seedbed, and soil moisture. Planting should be delayed until after rain or an irrigation, if the top 3 inches of soil is dry.

a/ 2.8 percent ethyl mercury 2,3 dihydroxy propyl mercaptide; and 0.6 percent ethyl mercury acetate.

b/ 2.2 percent methyl mercury dicyandiamide.

Some recommended planting dates are as follows:

Nov. 1-Jan. 15	Arizona	Safford, Nov. 1-Dec. 1; Salt River Valley, Dec. 1-Jan. 1; Yuma, Dec. 15-Jan. 15.
Nov. 10-Feb. 15	Southern California, New Mexico	Lower San Joaquin, Imperial, Palo Verde Valleys, California, before Feb. 15.
Feb. 1-March 1	Central California	Upper San Joaquin and Sacra- mento Valleys.
Feb. 1-April 1	Northern California	
March 25-May 10	Western Nebraska	
Early to mid-April	Southwestern Washington	
April 10-May 10	Montana, North Dakota, South Dakota	
April 15-May 1	Idaho, Wyoming	
Late April	Palouse Area, Washington	

Safflower may be planted in the fall on weed-free land in areas where winter temperatures remain above 20° F. It can withstand temperatures below freezing when it is in the early rosette stage. In the next--or stem-growing stage--freezing temperatures may damage safflower. Therefore it should not be planted before November in mild climates where it will reach the stem-growing stage before temperature drop to 32°.

Because safflower may be crowded out by weeds in its early stages, it should not be planted in the fall on land where weeds are a major problem.

In the Northern Great Plains, safflower should be planted as early in the spring as possible after the frost is out of the ground and temperatures below 20° F are unlikely. Early spring planting usually produces highest yields. However, planting on dryland should be delayed until the soil contains adequate moisture. Safflower planted after mid-May in the northern areas may be damaged by killing frosts before the seed matures.

Summer-planted safflower has produced low yields in experiments in California.

CULTURAL PRACTICES

Soil Preparation

Prepare a seedbed that is free of weed seeds and seeds of other crops. Plow as soon as possible following a crop of wheat or other small grain. Fall plowing is the best preparation for spring-planted safflower if there is no danger from erosion during the winter.

When safflower is grown after fallow, use tillage methods that leave sufficient crop residue on the soil during winter months to prevent soil blowing.

Allow weed seeds, volunteer wheat, and other small grains to germinate. These should be destroyed immediately before planting, by using a plow, disk, duckfoot, rodweeder, or one-way. Two spring tillings sometimes may be necessary.

The seedbed should be free from large clods, with a firm soil surface. Soil moisture should be about 1 inch below the surface of the soil.

Fertilization

Where nitrogen gives an increase in yield with other crops, it will benefit safflower. Nitrogen will not increase yields on most soils following alfalfa, sweet clover, or fallow.

The amount of commercial fertilizer to be applied is dependent upon the natural fertility of the land and the amount of available moisture. Use 20 to 40 pounds of nitrogen per acre on most land. If more than 1 1/2 tons of straw were returned by the previous crop, use about 50 pounds of nitrogen per acre. Apply commercial nitrogen fertilizer and work it into the seedbed before planting.

In Arizona where safflower may be grown under intensive irrigation, 60 pounds of nitrogen is recommended at planting time and 40 to 50 pounds before the budding stage.

Phosphate should be applied to soils where other crops show a response.

Planting

Safflower may be planted by solid drilling or in cultivated rows. Solid drilling, which is used most often in dryland areas, produces heavy stands of safflower. In some areas seed from solid drilled safflower may contain 1 or 2 percent more oil than row-planted seed. Safflower is usually planted in rows when it is grown under irrigation or when weeds are a problem.

Safflower may be planted with a grain drill. The seed runs through a drill faster than barley. To plant 30 pounds per acre, set the drill to seed about 20 pounds. Drills set for 3 pecks of wheat will deliver about 30 pounds of safflower per acre.

Plant seed between 1 and 2 inches deep into moisture for best results. Seedlings will emerge from a depth of 4 inches in moist soil if a crust does not form on the soil surface.

Solid drilling. Drill rows 6 to 12 inches apart for solid stands. The seeding rate will vary from 15 to 40 pounds of seed per acre on dryland areas. On irrigated land solid-drilled safflower should be sown at the rate of 20 to 50 pounds of seed per acre. Lower rates should be used in the fall when the crop is competing with weeds. Higher rates may be used in spring plantings after winter weeds have been killed. Lower seeding rates are used when moisture is scarce. Stands of 3 or 4 plants per square foot are best. Weeds may become serious in stands with less than two plants per square foot. If more than six plants per square foot emerge, overcrowding will reduce yields.

Rows. Cultivated rows may be planted at the rate of 8 to 20 pounds per acre for dryland and 20 to 25 pounds per acre under irrigation. Cultivated rows should contain 5 to 12 plants per foot of row. Rows usually are spaced 18 to 24 inches apart. This spacing provides room for cultivation of weeds and for irrigation. Safflower that is furrow irrigated should be planted in rows 20 to 30 inches apart. Sometimes irrigated safflower is sown on beds 40 inches from center to center with a pair of rows 14 inches apart on each bed.

Broadcasting. Safflower may be broadcast on moist soil. Broadcasting is not recommended for late plantings, when soil has begun to dry. When broadcast seeding, use about 10 pounds more than the rates recommended above. After broadcasting the seed, harrow to cover to a depth of 2 to 4 inches.

Cultivation and Weed Control

Control weeds in safflower by adopting a good crop rotation plan and by cultivating the crop at the proper time. Chemical weed killers do not work well in safflower, and hand hoeing is too expensive to be practical.

Row-planted safflower may be cultivated two or three times to control weeds. Harrowing is not recommended for furrow-planted safflower because it may bury the seed so deeply that it cannot germinate.

Weeds may come up before the safflower emerges if rainfall occurs soon after planting. Most of the small weeds can be destroyed by shallow harrowing.

Cultivate seedbeds before safflower plants come up or after a few plants have emerged. Work the field with a harrow, rotary hoe, or finger weeder diagonally or crosswise to the direction of seeded rows. Set the teeth fairly straight and weight the harrow. Select an afternoon with a high temperature and bright sun to harrow safflower.

Between the time plants come up and the time they reach a height of 3 inches, harrowing will cover them and reduce stands somewhat.

Safflower can be harrowed a second time when plants are between 3 and 6 inches high--if weeds remain a problem. However, cultivation will not destroy weeds that are the same size as safflower plants. The crop will compete well with small weeds in solid-drilled fields after it reaches a height of 6 inches. Safflower begins rapid growth after it is 6 inches high.

When weeds are harrowed before safflower reaches a height of 6 inches, hoeing usually is not necessary. Hand hoeing is difficult after spines appear.

The final cultivation for row-planted safflower should be made just before the crop begins to flower. Cultivate row-planted safflower in the same manner as other row crops.

None of the chemical weed killers tested in 1957 were suitable for use on safflower. The crop can be severely damaged by 2,4-D, other hormone type herbicides, and dinitro selectives.

New herbicides are being developed rapidly. Consult with your county agricultural agent or the state agricultural experiment station for the latest information on weed control in safflower.

Irrigation

Although plants need adequate moisture from planting through flowering, water is most important at the budding stage. Irrigation may increase safflower yield when soil moisture is low. Soil moisture, rain, and temperatures affect the number of irrigations needed during the growing season. Safflower is sensitive to too much water. The crop may be killed if water stands in a field for more than a few hours. Usually maximum yields require 2 to 5 irrigations if rainfall is inadequate during the growing season.

Safflower needs preirrigation in areas where small grains need preirrigation. A fall-planted crop in the Southwest needs preirrigation. Do not irrigate after plants come up until stems develop. During this period irrigation will benefit weeds which compete with safflower.

With only one irrigation after emergence, apply water when plants first begin to bud. This irrigation may be fairly heavy.

With two irrigations, apply water first about 4 or 5 weeks after safflower begins to grow erect. Irrigate again about 7 to 10 days after flowering.

If needed, apply additional lighter irrigations at 2-week intervals until the end of the flowering stage.

In the Great Plains, irrigate in late June, soon after buds start to form; in mid-July after flowering; and in early August before flowering ends. In California irrigate fall-planted safflower 3 to 5 times, as needed.

Apply an irrigation immediately if leaves begin to fire or wilt. Firing may decrease yields.

Avoid overirrigation. Water-logged soil may result in drowning or root rot. Irrigation may be applied in furrows, by flooding, by subirrigating, or by overhead sprinklers.

Subirrigation has many advantages. This method is used when safflower follows wetland crops--such as rice--on high water table land. Previous irrigations leave enough soil moisture to bring safflower to the flowering stage without danger of flooding or root rot.

For row-planted safflower, use furrow irrigation. Furrows should be about 20 to 24 inches apart and deep enough to avoid flooding. Prepare furrows about 7 to 10 days after safflower begins branching.

For solid-planted safflower, use flood irrigation. Avoid ponding at lower ends of the checks, if possible.

Overhead sprinklers may be used until safflower reaches the bud stage. Later use of sprinklers may result in disease development.

HARVESTING

Safflower will mature in about 120 days under favorable conditions. Cool weather, rain, or early frost may delay maturity.

The crop is easy to harvest because the seed does not shatter readily. It is ready for harvest when blooms disappear and the seed is hard and dry.

Test for maturity by squeezing several of the most recently developed heads. If the seed separates easily, it can be threshed. Green or wet seed is hard to thresh and will not store well if it has more than 8 percent of moisture.

The crop can be combined as soon as it is mature. It can be left in the field for as long as 30 days but some loss at harvest time may result. Light rains or frost after maturity will not harm it greatly.

If the seed will be used for planting, harvest it as soon as it is mature.

A pre-harvest contact weed killer may be used when late-maturing or green weeds make direct combining impossible. To make the spray, mix 1 quart of herbicide (Sinox General or Dow General) in 15 gallons of diesel oil per acre. Sometimes the crop may be swathed and allowed to dry before threshing with a combine with pickup attachment.

Safflower cannot be threshed as fast as barley or wheat. Adjust the speed of the combine so that few seeds are cracked in threshing. Combines with either tooth or bar cylinders may be used.

Remove concave teeth or reduce to 1 or 2 rows. Teeth should just begin to mesh with cylinder teeth. Adjust rub- or bar-type cylinders to 1/2-inch clearance between concaves and cylinder or sufficiently close to thresh all the seed without damage.

Safflower may shatter if the reel slats strike ripe seed heads directly. Modify the reel by attaching 4 to 6 inch strips of flexible belting to the slats. Raise the reel so that only the top of the belting hits the plants. Equalize the speed of the reel with the slow forward speed of the combine. If the heads catch on the slats, plug the space between the reel arms with plywood, canvas, or mesh wire screen.

Lower the cutter bar to cut fairly long stalks. Short stems may plug rattle rakes.

Set shaker screens slightly faster than usual. Adjust wind speed to remove the light seed but no filled seed. Enough wind is needed to blow away the fuzz from the seed. A screen may be placed in front of the radiator of the combine engine to prevent this fuzz from clogging the radiator.

Adjust the sieve so that it will remove small sticks, leaves, and stems.

Plants which have been lodged by hail can be combined with the use of a pickup guard.

Handle threshed safflower seed in bulk, if possible. When the seed is sacked during harvest, sacks pick up spines from the fields.

Safflower is difficult to harvest without a combine because of the spines.

INSECTS

Insects have caused only minor damage to the total safflower crop. However, they have caused substantial loss in certain individual fields and at times control measures are warranted.

Lygus bugs damage the heads causing them to fail to develop, to become discolored, or to develop rot. They may be controlled by one or two applications of DDT (3 quarts of 25 percent DDT in 10 gallons of water per acre) at the time buds are developing. Lygus bugs have been most serious in late-sown fields.

Grasshoppers feed on safflower usually after small grain harvest. Damage is usually confined to the margins of fields.

Wireworms may cause poor stands. Treatment of the seed with lindane gives satisfactory control.

Aphids, leaf hoppers, and the larvae of the sunflower moth have caused occasional damage.

DISEASES

The most prevalent diseases of safflower in the United States are rust (Puccinia carthami corda), root rot (Phytophthora drechsleri Tucker), leaf spot (Alternaria carthami), and bud rot. The amount of damage they cause is dependent primarily upon weather conditions, cultural practices, and the variety. These diseases cause a sizeable loss in total production but they are not regarded as extremely serious except in some local areas and in regions where safflower is not adapted.

Phytophthora root rot has made production of present safflower varieties unprofitable under flood irrigation in California. Most of the acreage, as a consequence, is on dry land or subirrigated land.

Rust

Rust may occur in any area in the United States where safflower is adapted. It is most prevalent in the northern Great Plains, and in the northern San Joaquin and Sacramento Valleys. High humidity from atmospheric conditions or from irrigation is necessary for rust to develop profusely. The disease is seldom a problem on dry land.

Rust may cause serious stand loss when it develops on the roots, crowns, and stems of young plants from either seed or soil-borne spores. The loss in yield from leaf pustules resulting from wind blown spores is not considered to be large except in cases where the disease becomes epiphytotic.

Seed treatment with a volatile mercury fungicide will give good but not perfect control of seed-borne spores. Crop rotation is recommended for control of soil-borne spores. Winter flooding of river bottom land in California has given adequate control of soil-borne spores. Control of leaf pustules is difficult. No varieties resistant to all races of the rust are available at present. The use of

rust-free seed, if available, may be of value, particularly in new areas of production. Late planted fields usually are affected less than early planted fields.

Root Rot

The fungus organism causing root rot of safflower is soil-borne and widely distributed in the Western United States. The disease has been most serious in the Southwest. High temperature and high soil moisture favor the development of the disease. Root rot is most severe on surface irrigated land and is seldom a problem on dry land or subirrigated land.

The disease usually develops after the first irrigation but it may occur at any time from emergence to well after flowering. Entire plantings may be completely destroyed by this disease. Affected plants dry up quickly and turn light green in color. The roots and lower stems are rotted and dark green to black in color.

Long irrigation runs and land with poor water penetration or drainage are to be avoided. Irrigations should be frequent enough to prevent safflower from suffering from lack of water and exhibiting a firing of the lower leaves. Growing safflower on beds with furrow irrigation rather than flooding is preferred since there is less danger of water standing. Varieties differ in their resistance to root rot. However, the present commercial varieties, N-10 and Pacific 1, are highly susceptible. Resistant varieties should be available for production in the near future.

Leaf Spot

Alternaria leaf spot has been serious only in Nebraska in irrigated plantings. The disease is likely to be present wherever and whenever dews and showers occur frequently during the middle and latter part of the growing season.

The disease produces large, brown, irregular spots on leaves and flower bracts. It discolours the seed and results in loss in yield and oil content.

The causal organism may be seed-borne and cause seed rot and damping-off. Seed treatment with a volatile mercury fungicide will give excellent control of the seed rot and damping-off phases of the disease. Present varieties have some tolerance to leaf spot. This disease is one of the factors which limit production to areas having dry atmospheric conditions.

Bud Rot

Bud rot is a serious problem where production is attempted in areas of high humidity or rainfall. In the eastern part of the Great Plains the trouble appears to be associated with insect injury to the buds. Various fungi, mostly Alternaria spp., invade the injured bud, causing it to become discolored, to shrivel, and to fail to develop. In the coastal areas of California subject to fog the buds are damaged by Botrytis. Bud rot, when severe, can affect most of the heads in an entire field causing marked reduction in yield.

Other Diseases

Verticillium wilt (Verticillium albo-atrum) and Fusarium root rot (Fusarium solani) have been observed in several States. These troubles have caused minor damage in the present areas of production. Neither is likely to be serious on dryland. Irrigated safflower may be affected in new areas where these diseases are serious on other suspects.

